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Integrated Risk Analysis for Extreme Storm Surges in GIS (XtremRisK)

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Introduction

The joint research project XtremRisK (Extreme Storm Surges at Open Coasts and Estuarine Areas – Risk Assessment and Mitigation under Climate Change Aspects) is aiming to improve the understanding of extreme storm surges and related risks which may result from expected climate change. The XtremRisK project brings together scientists from three universities in Germany and the responsible coastal and harbour authorities. The project commenced in 2008 and will be completed by June 2012 (Oumeraci et al., 2009).
The overall aim of the project is to enhance the knowledge with respect to the uncertainties of extreme storm surge predictions as well as to quantify the overall flood risk for two selected pilot sites in Germany representing the open coast (Island of Sylt) and estuarine areas (Hamburg).
For the integrated risk analysis, a source-pathway-receptor concept is used (see Oumeraci, 2004). The integrated risk analysis comprises the prediction of extreme storm surges (risk sources), defence failure probabilities (risk pathways), and the determination of subsequent losses (risk receptors). Finally, all results are merged within the integrated risk analysis (risk integration) (Burzel et al., 2010).

Methods and Results

In XtremRisK at least five extreme storm surge scenarios will be analysed. In order to enhance knowledge about risk sources, the analysis of the physical characteristics of extreme storm surges is essential. The objective is to investigate extreme values of storm surge components wind surge, tide and external surge and their nonlinear interaction. To estimate the occurrence probabilities for each scenario, a methodology based on multivariate statistics has been developed (Wahl et al., 2010).
Analysing the risk pathway, structural and non-structural failure modes have been investigated. The failure probabilities were calculated for the whole flood defence system, subdivided into 84 sections (Naulin et al., 2010). Based on these results, the initial hinterland flooding conditions were derived.
Following, two dimensional numerical flood simulations were performed using the open source platform Kalypso•RMA to determine the flooding for each storm surge scenario. The results have been used for the analysis of the risk receptors, i.e. tangible and intangible damages.
The damage analysis is carried out on a spatial basis by comprehensive geoprocessing models in ArcGIS. For this reason, a methodology has been developed to use fishnet raster for risk calculations. As a first step all input data were converted into the fishnet format. In a second step, the fishnets are used for the spatial calculation of both, tangible and intangible losses, such as damages on residential and industrial buildings, and the estimation of injuries and fatalities within the pilot site.
For this purpose, the loss-of-life-model presented by Penning-Rowsell et al. (2005) has been brought into spatial context. All relevant information such as the population distribution within the pilot site, flood characteristics and area properties were converted into high resolution fishnets. In addition to tangible damages, a comprehensive geoprocessing model is available for the spatial estimation of injuries and fatalities for each storm surge scenario. A model for cultural damages is under development.
Finally, tangible and intangible damages are integrated in order to obtain the overall flood risk. Therefore, an integration approach based on the Multiattribute Utility Theory (MAUT approach, see Malczewski, 1999) has been applied in GIS. This approach enables the consideration of tangible and intangible damages in an integrated risk analysis. Based on the analysis, flood risk reduction measures will be proposed at the end of the project.
The XtremRisK project, the described methodology as well as results from the integrated risk analysis will be presented at the conference. The integration of tangible and intangible damages as described above will be emphasised.

Website

Further information about the XtremRisK project and intermediate results are also presented at the project website under www.xtremrisk.de.

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